(12) UK Patent Application (19) GB (11) 2 362 115 (13) A

(43) Date of A Publication 14.11.2001

(21) Application No 0011395.1

(22) Date of Filing 12.05.2000

(51) INT CL[7]
F01N 3/02 , B01D 49/00

(52) UK CL (Edition S)
B1T TACA TXAA
F1B BFA BFK BF101 B2W

(56) Documents Cited
GB 1419823 A EP 0551162 A2 EP 0488097 A1
WO 87/04641 A1 DE 019846115 A US 5197399 A

(58) Field of Search
UK CL (Edition R) B1T TACA TXAA
INT CL[7] B01D 49/00 , F01N 3/02
Online: WPI, EPODOC, JAPIO

(71) Applicant(s)
Ford Global Technologies Inc
(Incorporated in USA - Michigan)
600 Park Lane Towers East, Dearborn,
Michigan 48126, United States of America

(72) Inventor(s)
Thomas Tsoi-Hei Ma

(74) Agent and/or Address for Service
A. Messulam & Co. Ltd
43-45 High Road, BUSHEY HEATH, Herts, WD23 1EE,
United Kingdom

(54) Abstract Title
Removal of particles from ic engine exhaust gas using sound

(57) An exhaust system for an internal combustion engine 10, comprises a separation chamber 14 through which exhaust gases together with any fine particles suspended therein are directed. Means 18, 20 and 22 are provided for generating standing acoustic waves within the separation chamber 14 to trap and promote agglomeration of the fine particles. The means for generating standing waves may be one or more acoustic wave generators 22, preferably assisted as shown by the pulsations in the exhaust system that are generated by the operation of the engine. A pressure sensor 18 measures the amplitude and frequency of the pressure pulses caused by the sequential opening of the different cylinders, and produces a signal to control the operation of the generator. Alternatively (Fig 2) in an engine with two banks (10a, 10b) of cylinders, the exhaust manifold (12a, 12b) from each bank is connected to opposite ends of the separation chamber to create interfering waves without the need for a separate generator. After removal of the particles, the gas exits the chamber 14 though tail pipe 16 leading to catalytic convertor and silencer. The agglomerated particles are compressed and discharged as pellets, or ignited and burned in the exhaust gas stream.

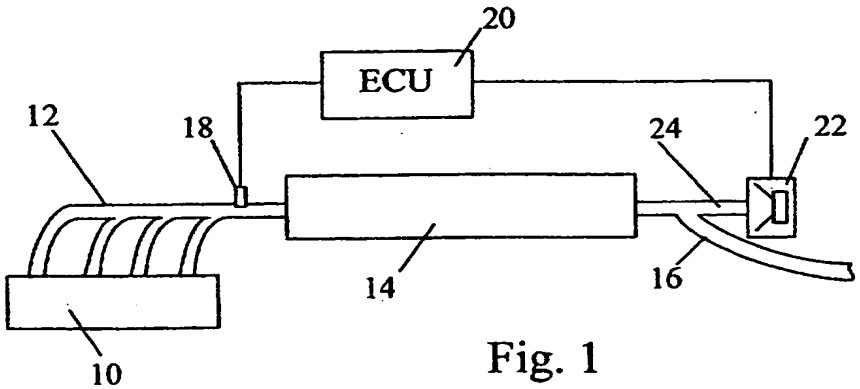

Fig. 1

BEST AVAILABLE COPY

GB 2 362 115 A

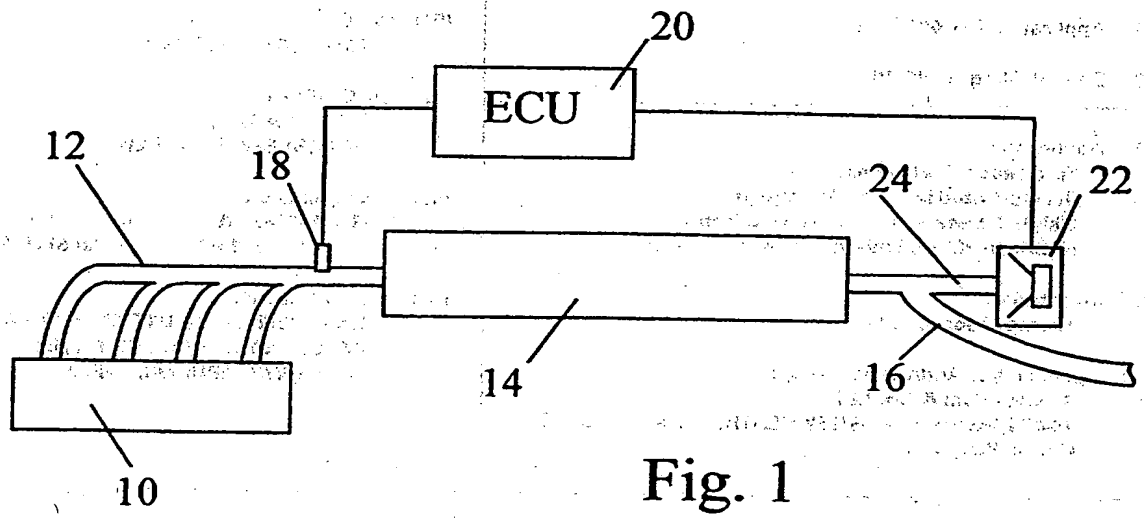

Fig. 1

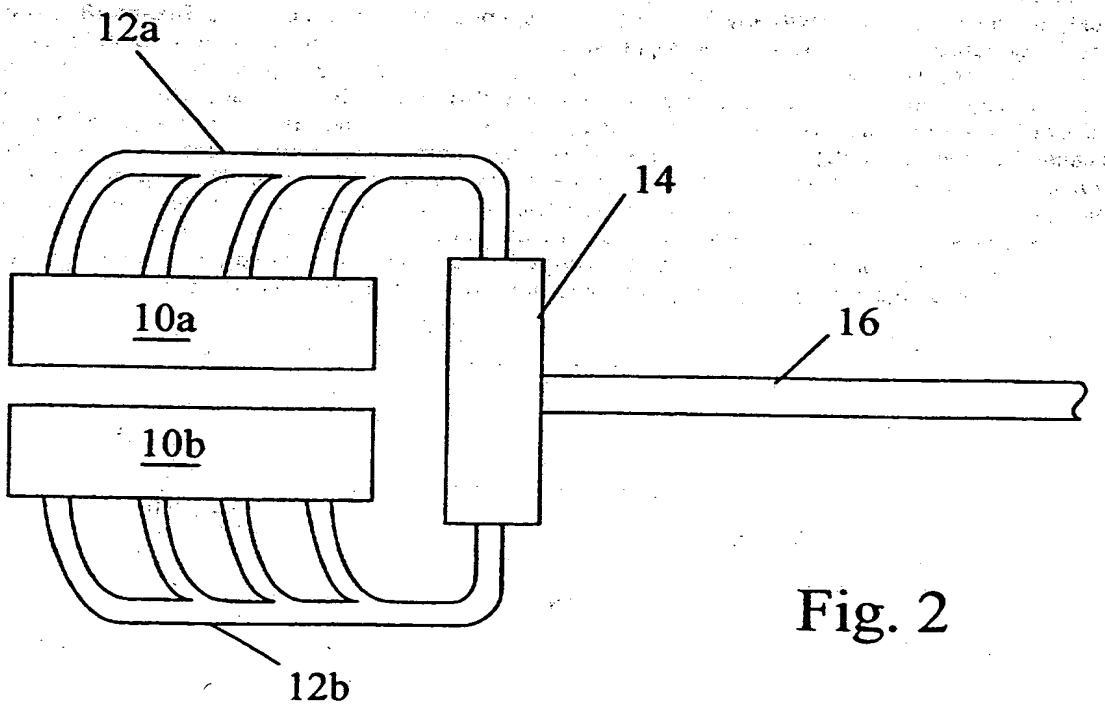

Fig. 2

BEST AVAILABLE COPY

BNSDOCID: <GB 2362115A I >

REMOVAL OF PARTICULATE MATTER FROM ENGINE EXHAUST GASES

Field of the invention

The present invention relates to purification of the gases emitted by an internal combustion engine and in particular to the removal of particulate matter from the exhaust gases.

Background of the invention

It is known to remove particulate matter from exhaust gases by the use of filters. One disadvantage of such an approach is that the filters become blocked and require regular attention, for example the engine must be periodically operated in a high temperature mode to clear the filter of stored particles. Filters also present resistance to gas flow and thus adversely affect engine performance.

Object of the invention

The present invention seeks to remove particulate matter from an engine exhaust system without resorting to the use of a filter.

Summary of the invention

According to the present invention, there is provided an exhaust system for an internal combustion engine, comprising a separation chamber through which exhaust gases together with any fine particles suspended therein are directed and means for generating standing acoustic waves within the separation chamber to trap the fine particles and promote agglomeration of the fine particles.

It has long been known that when a standing wave is set up in a tube containing dust, the dust particles tend to collect at the nodes of the standing acoustic waves. The present invention makes use of this behaviour of suspended particles to separate them from the exhaust gas stream. By setting up an acoustic standing wave in a chamber in the exhaust system of an engine, the fine particles are made to collect, collide and agglomerate to form larger particles of sufficient size not to be carried by the gas stream but to drop under gravity to the bottom of the separation chamber. The larger particles of agglomerate act as nuclei to collect more and more fine particles and to absorb other non-solid contaminants such as sulphur dioxide and volatile organic compounds, so that all the fine particles and particle forming compounds are separated from the exhaust gases.

Several possibilities present themselves for the creation of an acoustic standing wave.

A first implementation would be to incorporate one or more sound generators in the separation chamber to set up standing acoustic waves within the chamber. This method of separating particles from gas streams has already been proposed for stationary installations such as power stations.

A sound generator of sufficient power and capable of withstanding the environment within an engine exhaust system could be costly to implement and could consume considerable engine output power. It is therefore preferred to make use of the pulsations in the exhaust system that are generated by the operation of the engine to assist in the generation of the standing acoustic waves in the separation chamber.

In one embodiment of the invention, it is possible to introduce the pulsating exhaust stream into one end of the separation chamber and to generate an acoustic wave at the

opposite end of the chamber in order to set up the desired standing wave. In this case, one of the two interfering waves resulting in the standing wave is naturally produced by the engine.

In an alternative and further preferred embodiment of the invention, pulsating exhaust streams from the engine are introduced from opposite ends into the separation chamber. In this case, the engine produces both of the interfering sound waves, obviating the need for a separate sound generator.

The pulsating exhaust gas streams fed to the opposite ends of the separation chamber may either be produced by splitting the entire gas flow from all the engine cylinders or by feeding the exhaust gases from one bank of cylinders to one end of the separation chamber and the gases from a different bank of cylinders to the other end of the separation chamber.

Once the particles have collected in the separation chamber, they may be removed without causing atmospheric contamination. One way would be to compress the particles mechanically (for example by the use of a screw) and to discharge them as solid pellets. The alternative would be to ignite the collect particles and burn them in the exhaust gas stream.

Brief description of the drawings

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which :-

Figure 1 is a schematic diagram of a first embodiment of the invention which relies partly on the engine induced pulsation and partly on an acoustic wave that is

independently generated to set up a standing acoustic wave in a separation chamber, and

Figure 2 is a schematic diagram of a second embodiment of the invention which relies on interference between pulsation produced by two different banks of cylinder to set up a standing acoustic wave in the separation chamber.

It is known from classical physics experiments that if two sound waves of the same frequency and amplitude propagate in opposite directions along a tube, then their interference will set up a standing wave. Furthermore, it is well known that any dust or fine particles suspended in the air in the tube will tend to collect at the bottom of the tube in specific regions of the standing wave and the vibration of the collected particles at these regions promotes their agglomeration into larger particles which come out of suspension more easily. The separation chambers 14 in both of the illustrated embodiments of the invention operate on this principle to separate fine particulate matter from the exhaust gases of an engine.

In Fig. 1, an internal combustion engine 10 has an exhaust manifold 12 with four branches (of preferably equal length) that leads to a separation chamber 14. The outlet of the separation chamber 14 is connected to a short stub pipe 24 that leads directly to a sound generator 22. The exhaust flow leaves the stub pipe 24 through a tail pipe 16 that branches from the stub pipe 24 and leads to conventional exhaust aftertreatment devices (not shown) such as a catalytic converter and a silencer.

A pressure sensor 18 measures the amplitude and frequency of the pressure pulses caused at the first end of the separation chamber 14 by the normal operation of the engine (resulting from the sequential opening of the exhaust valves of the different cylinders). The output signal of the pressure sensor 18 is applied to an ECU 20 which drives the

BNSDOCID: <GB 2362115A >

sound generator 22 to produce acoustic pulses of the same amplitude and frequency at the opposite end of the separation chamber 14. The two identical acoustic waves or pressure waves interfere as earlier described to produce a standing wave in the separation chamber 14 and cause the particles in the exhaust flow to settle in the separation chamber 14. The exhaust gases leaving the separation chamber 14 flow down the tail pipe 16 after they have passed through the standing wave.

The embodiment of Figure 2 shows the realisation of the invention in an engine with two banks of cylinders 10a and 10b. In such an engine, two acoustic waves of the same frequency and amplitude are always generated in the exhaust manifolds 12a and 12b of the two banks regardless of engine speed and load operating condition. These acoustic waves can therefore interfere with one another in the desired manner when applied to the opposite ends of the separation chamber 14, avoiding the need for a separate sound generator. In this case, the exhaust flow can exit from the separation chamber 14 along the tail pipe 16.

Once the particles have been driven out of suspension in the gas flow and converted into an agglomerate that settles at the bottom of the separation chamber 14 any desired means may be used to dispose safely of the resultant agglomerate. For example it may be ignited and burned in the exhaust system or compressed and discharged from the chamber in the form of safely disposable pellets.

CLAIMS

1. An exhaust system for an internal combustion engine, comprising a separation chamber through which exhaust gases together with any fine particles suspended therein are directed and means for generating standing acoustic waves within the separation chamber to trap the fine particles and promote agglomeration of the fine particles.

2. An exhaust system as claimed in claim 1, wherein at least one acoustic wave generator is incorporated in the separation chamber to set up standing acoustic waves within the chamber.

3. An exhaust system as claimed in claim 1 or 2, wherein use is made of pulsations in the exhaust system generated by the operation of the engine to assist in the generation of the standing acoustic waves in the separation chamber.

4. An exhaust system as claimed in claim 3, wherein means are provided to introduce the pulsating exhaust stream into one end of the separation chamber and further means are provided to generate an acoustic wave at the opposite end of the chamber in order to set up the desired standing wave.

5. An exhaust system as claimed in claim 3, wherein means are provided for introducing pulsating exhaust streams from the engine from opposite ends into the separation chamber.

6. An exhaust system as claimed in claim 5, wherein the pulsating gas streams fed to the opposite ends of the separation chamber are produced by different banks of engine cylinders.

7. An exhaust system for an internal combustion engine, constructed and adapted to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

PATENTS • DESIGNS • COPYRIGHT • TRADE MARKS
The Patent Office
INVESTOR IN PEOPLE

Application No: GB 0011395.1
Claims searched: 1-7
Examiner: Bridie Collier
Date of search: 3 August 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): B1T (TACA, TXAA)

Int Cl (Ed.7): B01D 49/00, F01N 3/02+

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 1409823 A	(SCOTT) See Page 1 line 16-23, and Cl 1	1,2
X	EP 0551162 A2	(YAMANE) See col 17 lines 3-5	1,2
X	EP 0488097 A1	(EURATOM) See abstract	1,2
X	WO87/04641 A1	(WESSLING) See abstract	1,2
X	US 5197399 A	(MANSOUR) See abstract	1,2
X	DE 19846115 A	(DAIMLER) See abstract	1,2

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.